Unveiling the AGN activity in multiple SMBH systems observed with XMM-Newton

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on behalf of MAGNA team

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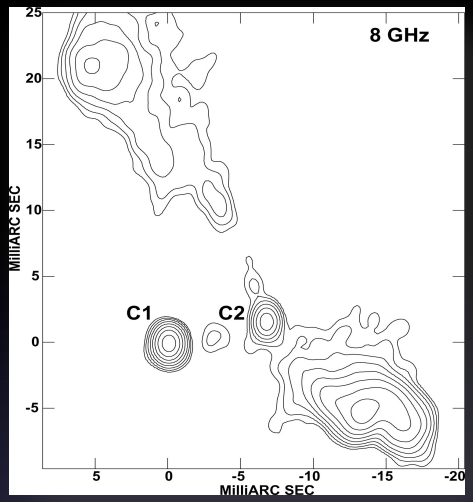
http://www.issibern.ch/teams/agnactivity/Home.html

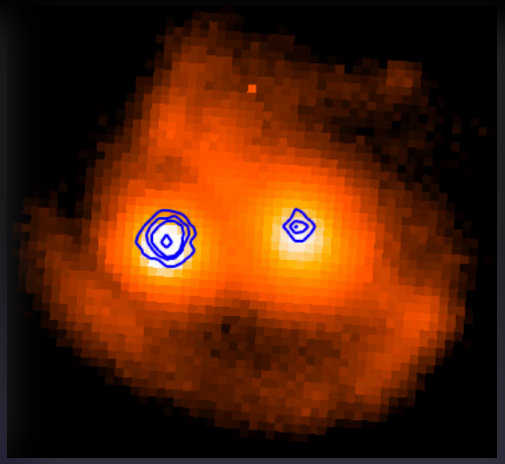
Multiple supermassive BH systems are of wide astrophysical relevance

- ✓ the main ingredients of triggering AGN and in and BHs-galaxy co-evolution (feedback) (Sanders+88,Hernquist+89,Kauffmann+00)
- ✓ triggering starburst activity (Taniguchi & Wada 1996)
- ✓ in the formation of molecular tori (Zier & Biermano1, 02)
- ✓ play a role in the formation of radio jets (Chiaberge+15)
- ✓ coalescing binary SMBHs are strong emitters of gravitational waves detectable with LISA.

AGN in merging galaxies however remain observationally elusive, thus raising a question about their characteristic observational signatures

Spatially resolved dual systems





- pc separation **radio**
- 0402+379: Two cores compact, variable & flat-spectrum → true nuclei sep 7 pc (Rodriguez+ 07)

- **IR selection**
- AGN hosts 0.5<z<1.5 , pc-kpc separations
- CDFS, C-COSMOS, AEGIS-XD. (Kocevski+15, Comerford+ 09, Elvis + 09)

- **X-ray (Chandra/ XMM)**
- kpc scale
- Mrk 739, NGC3340, NGC 6240 (Komossa +03, Koss+11, Ricci +17, Bianchi+13, Guainazzi+05)

- **Hard-X (Swift/ BAT, Nustar)**
- 250 kpc-Mpc (Swift/BAT)
- NGC6286, NGC 6285 33 kpc (Koss+11, 12, Ricci+17)

separation

Selection bias?

Fraction of mergers increases with obscuration

*obscured SMBH growth is a distinct phase in an evolutionary sequence following a merger event. (*Kocevski+15)

- **X-ray**: High penetrative (Koss+11, 16; Ricci+17) BUT heavily obscured AGN are not sampled in X-rays (Treister+04)
- **IR**: merger fraction higher with respect to optical selection (Satyapal +14) BUT AGN identification - See N. Loiseau's Poster J17
- **radio** is powerful BUT biased against RQ AGN

MAGNA goal is the first systematic study of a well defined sample of multiple SMBHs **using multiband information**

MAGNA-Master Sample (MMS)

- AGN systems optically classified (SDSS, Liu+11)
- Sy-Sy systems through emitting line diagnostic - BPT diagram
- Max proj. dist = 60 kpc (only interacting systems)

(almost) Final sample of 16 Systems

- Proj. disc ≈ 10-60 kpc and z≈0.03-0.17
- XMM AO15: 4 systems with ang sep. >10" (~200 ks)
- Chandra proposal for the systems with ang sep. <10"
- All systems granted to MAGNA be observed with VLA

See Poster J17 on IR selected sample N. Loiseau

MAGNA-Master Sample (MMS)

- SDSS J0959+1259 : An exceptional AGN rich Compact Group (ADR & Magna, 2015, MNRAS, 453, 214
- 4 dual systems of MMS observed with XMM (ADR & Magna in preparation)

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The quintet group SDSS J0959+1259

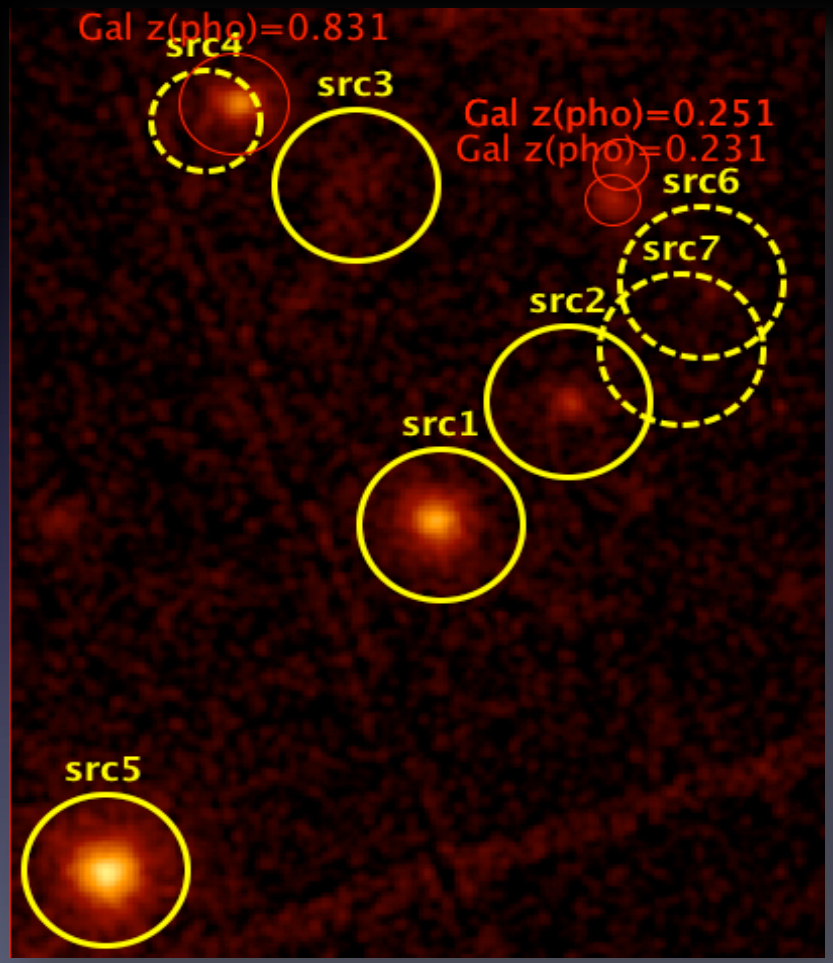
De Rosa & MAGNA team, 2015, MNRAS, 453, 214.

Composite gri SDSS image (100"x100")
z=0.03

- ✓ The only Quintet group in the huge optical sample (Liu+11)
- ✓ XMM 20 ks exposure
- ✓ Follow-up 2.2 m telescope in Calar Alto BUSCA optical image higher sensitivity than SDSS

The crowded field

XMM pn+MOS12



BUSCA R-filter

~200 kpc (4.5 arcmin)

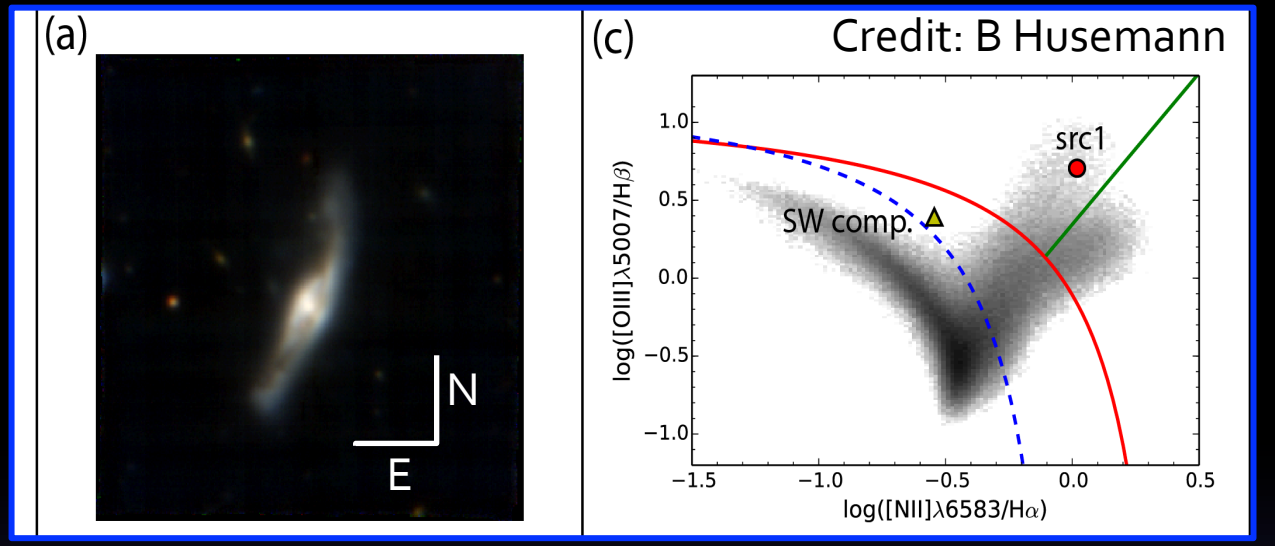
De Rosa+ 2015

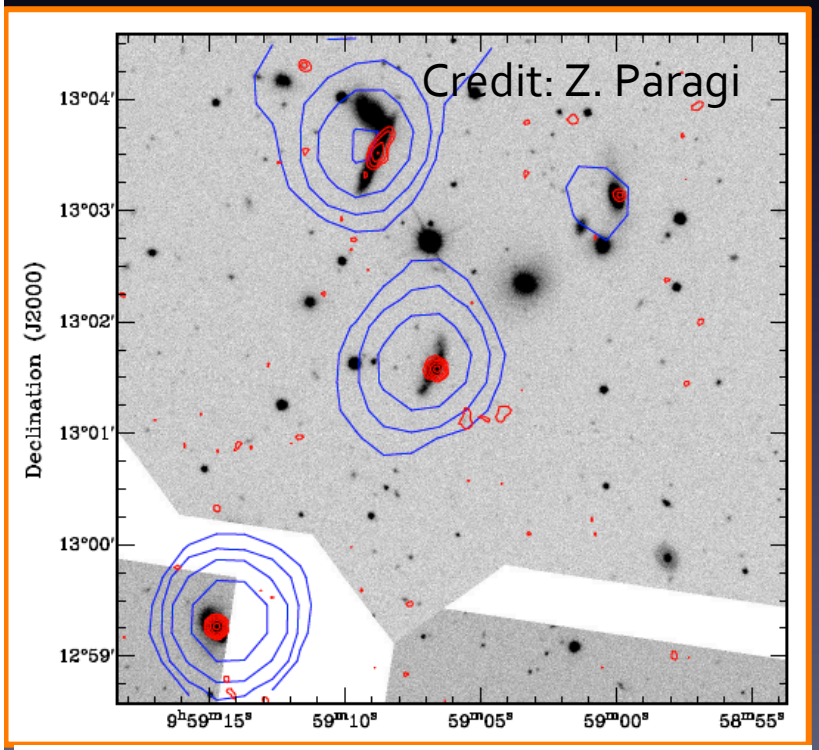
HCG J0959+1259 a case study

- High Fraction of AGN/LINERs: 60% (5 over 8)
- X-ray study of 18 CG (Lx>1e40 erg/s, B mag <18) showed less than 1 AGN/group (Silverman+14)
- SFR enhanced
- Richness HI gas – tidal signature/distortion
- very low [NII]/Hα possibly due to recent interaction

All these properties allow detailed, spatially resolved mapping of the distribution and kinematics of the stellar and gaseous components

VLT-MUSE
VLA-eEVN





SDSS with NVSS and FIRST

- ✓ A strong galactic wind in the ionized gas perpendicular to the gal disk
- ✓ A prominent ionized gas region to the SW, possibly indicative of a gas outflow
- ✓ BPT: AGN-dominated region and the SW component in the star-forming region.
- ✓ AGN jets on 1-100 pc scales / jet-induced star formation
- ✓ The HI content in group members and intragroup medium (VLA)
- ✓ The amounts of neutral (VLA HI) and ionized (MUSE Ha & [O iii])→ feedback

MAGNA-Master Sample (MMS)

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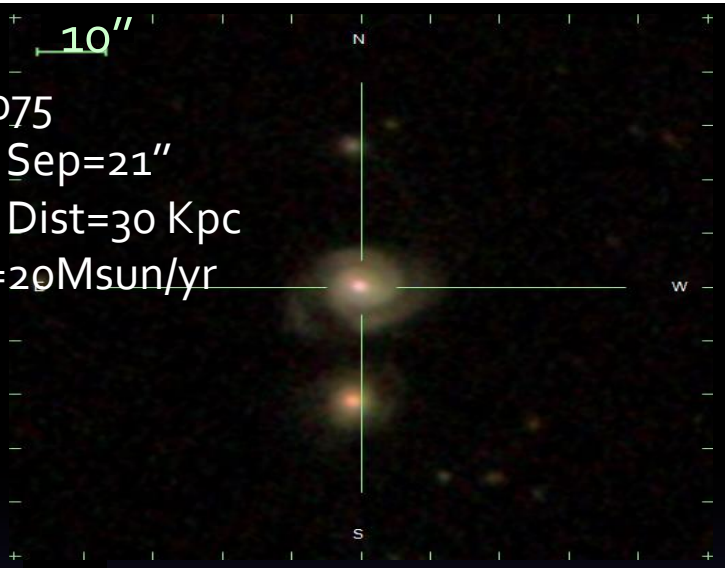
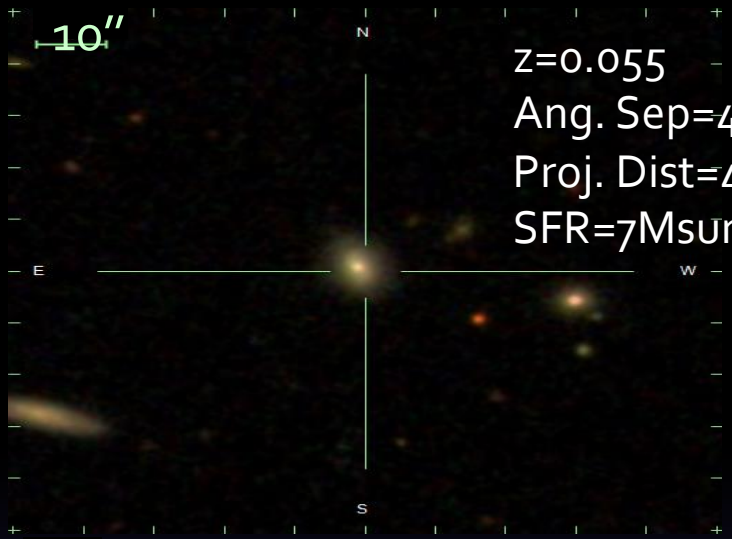
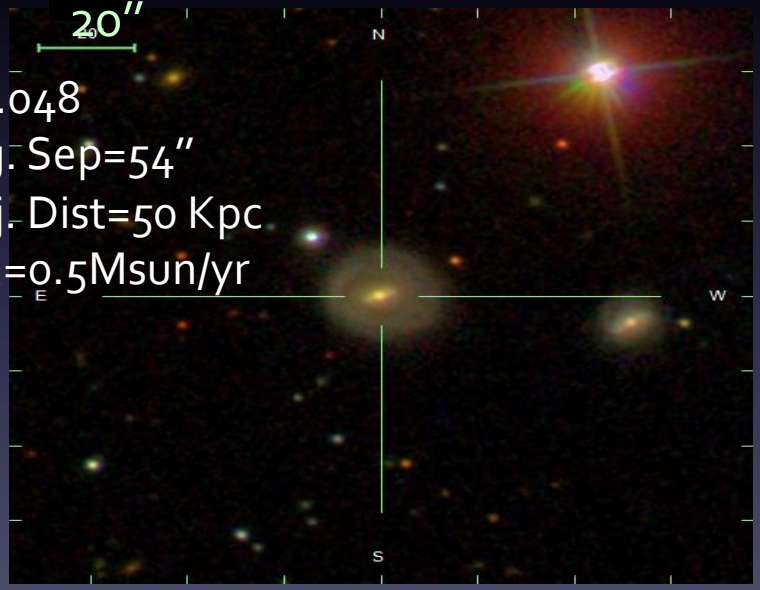


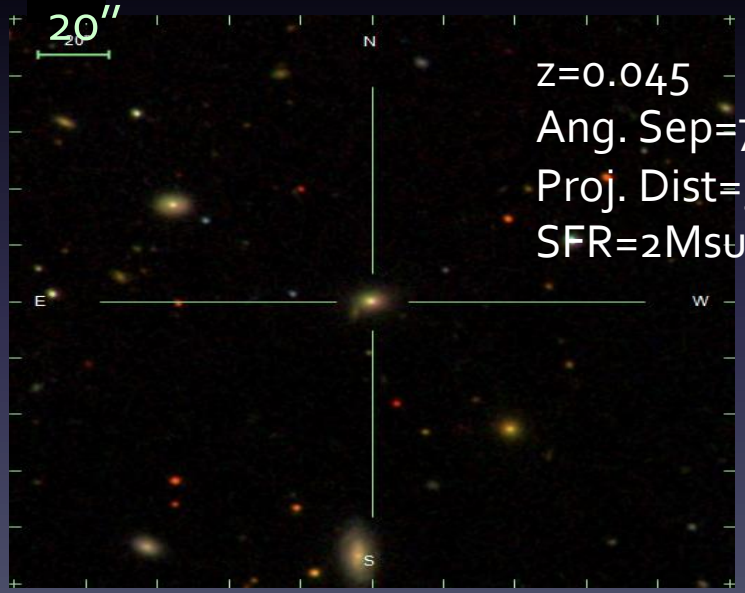
z=0.075
Ang. Sep=21″
Proj. Dist=30 Kpc
SFR=20Msun/yr



z=0.055
Ang. Sep=40″
Proj. Dist=43 Kpc
SFR=7Msun/yr



z=0.048
Ang. Sep=54″
Proj. Dist=50 Kpc
SFR=0.5Msun/yr

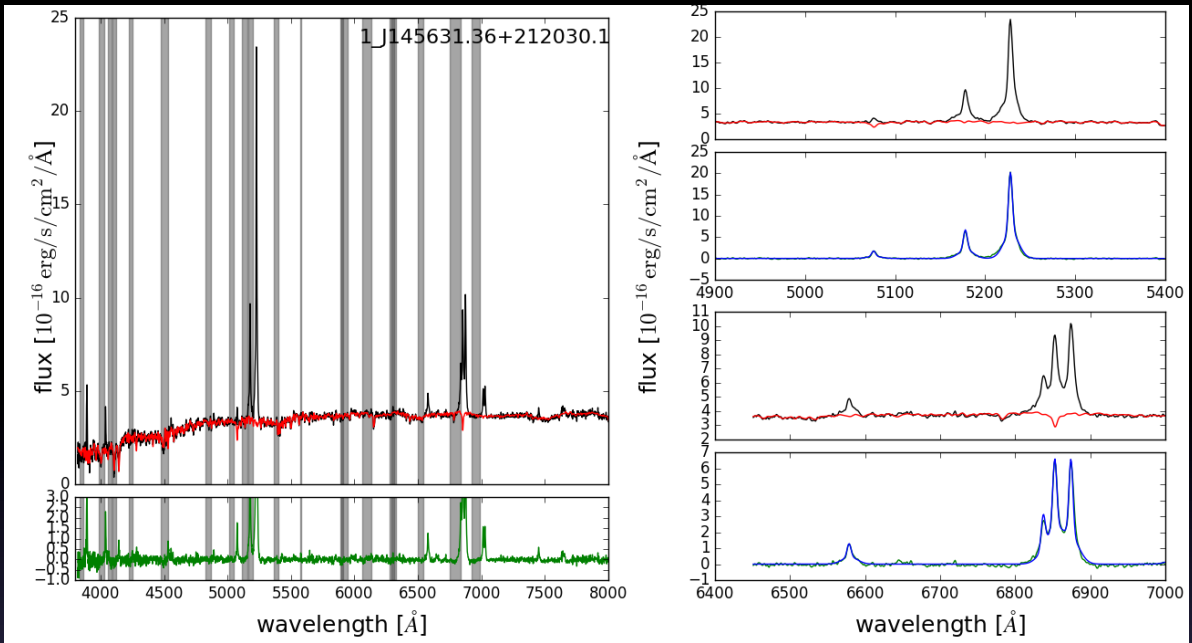


z=0.045
Ang. Sep=70″
Proj. Dist=59 Kpc
SFR=2Msun/yr

SFR from SDSS+WISE SED. Chang+15

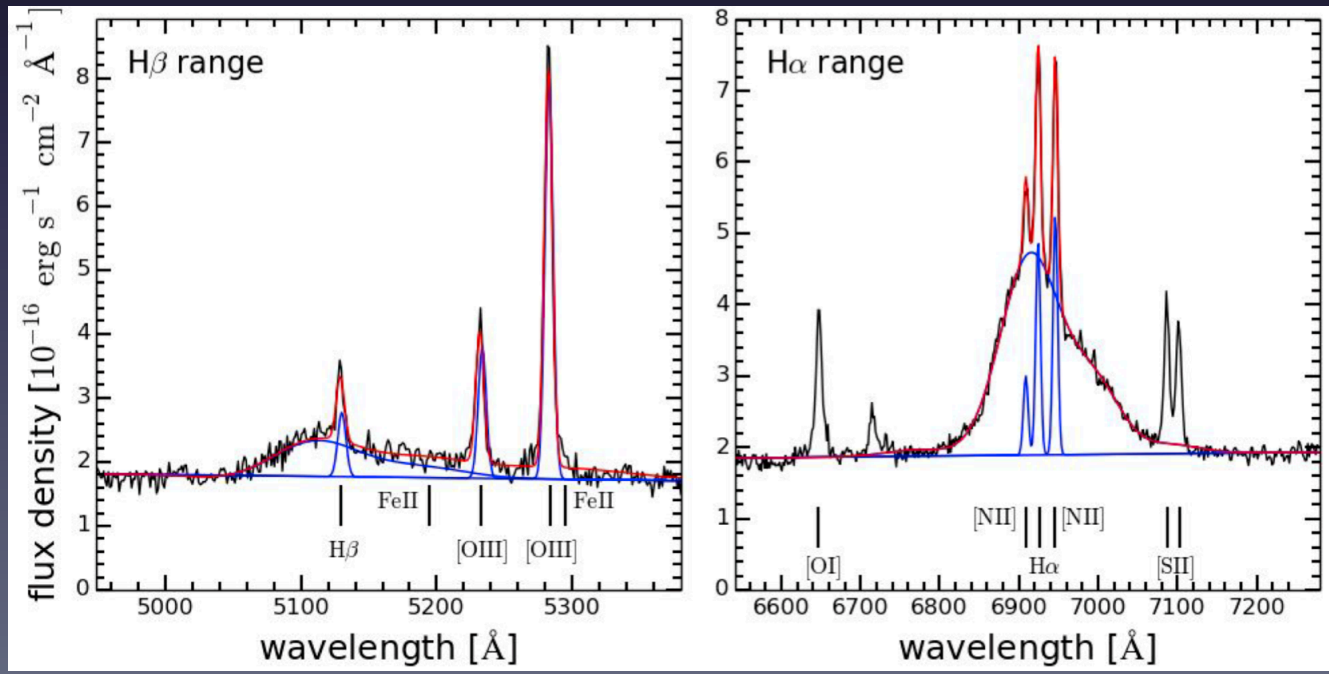
SFR increases with decreasing separation

SDSS spectroscopy

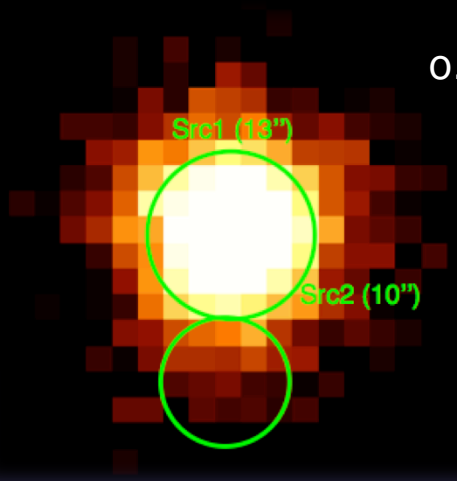


Type 2 AGN.
in the closest systems.
Evidence of outflows of about ~1000 km/s

Type 1 AGN
BHM=5.7x10^7 Msun
log Lbol = 43.8 in agreement with X-ray measurement



XMM observations I

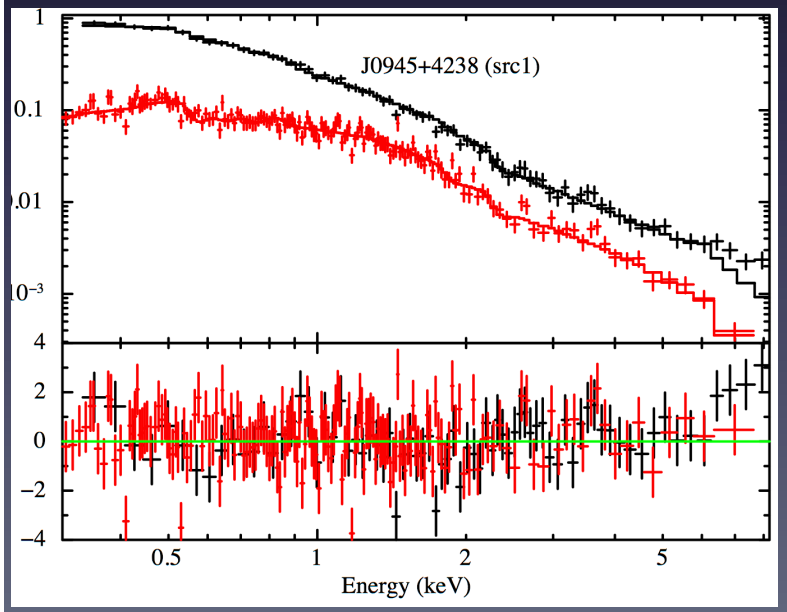


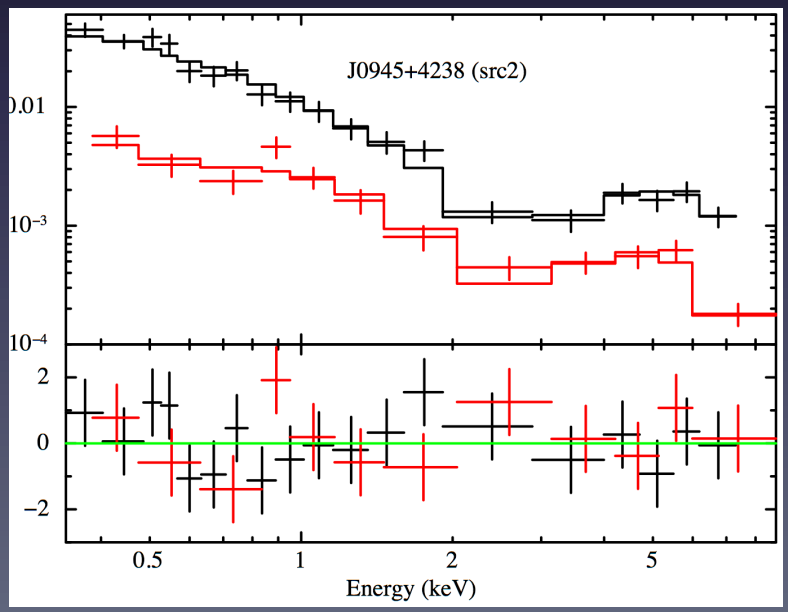
$\Gamma(1,2)=2.4,\ 1.7$

$Nh(1,2)=0,\ 25 \times 10^{22}\ cm^{-2}$

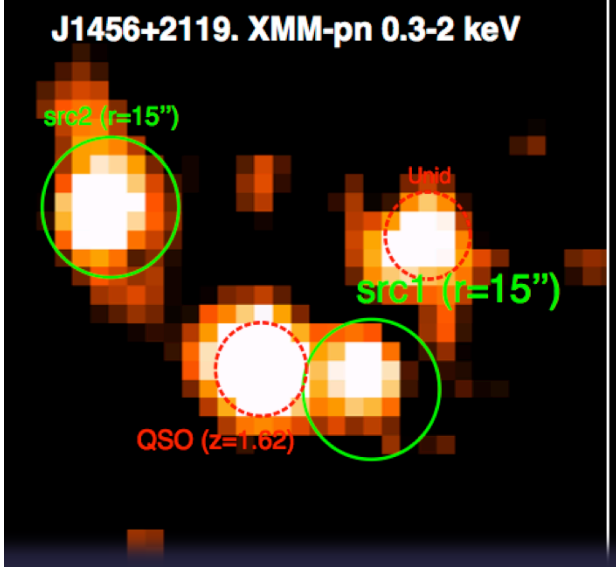
$Lx(1,2)=7,\ 3 \times 10^{42}\ erg/s$

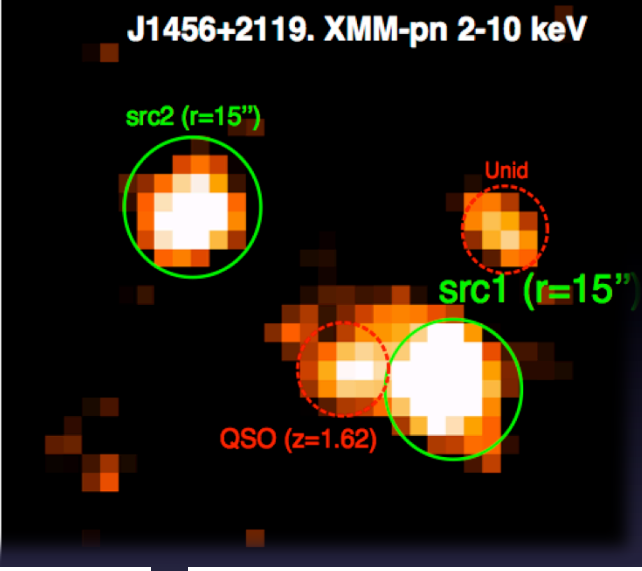
Type 1 and type 2 AGN



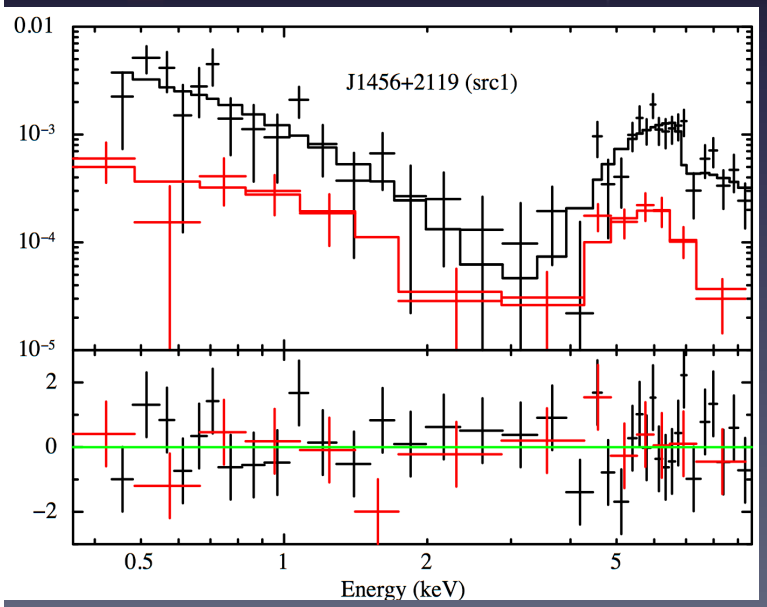


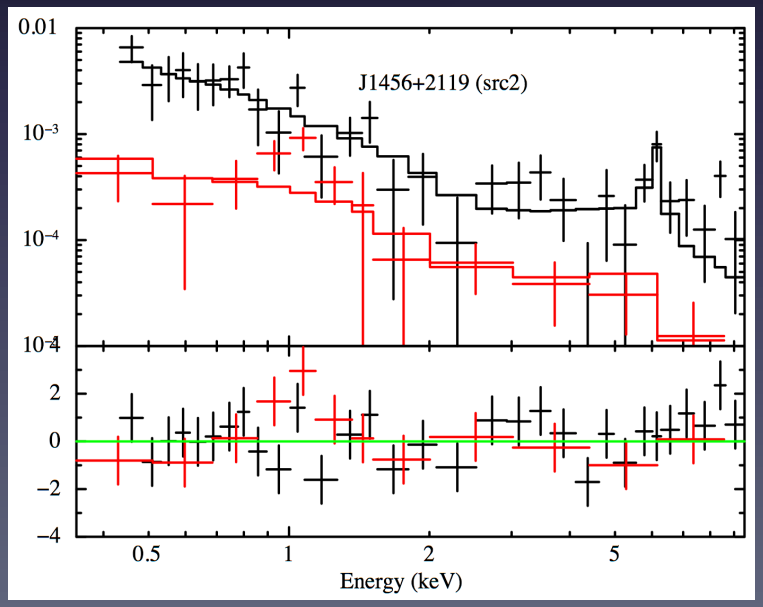
XMM observations II





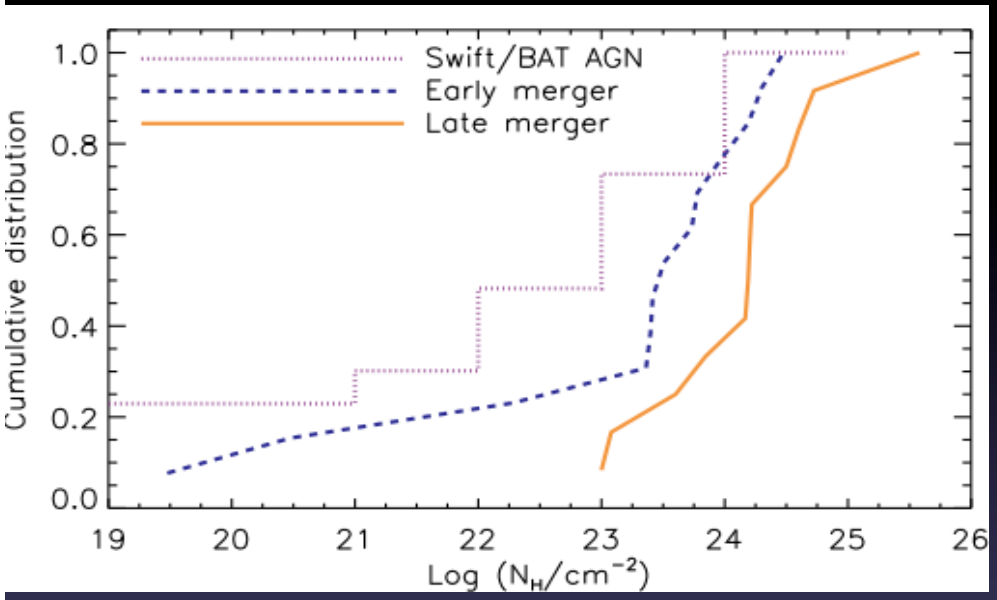
Γ(1,2)=1.9, 1.7
Nh(1,2)=73, 81 x 1e23 cm^{-2}
Lx(1,2)=4, 6x1e42 erg/s
O[III]/X suggests CT AGN

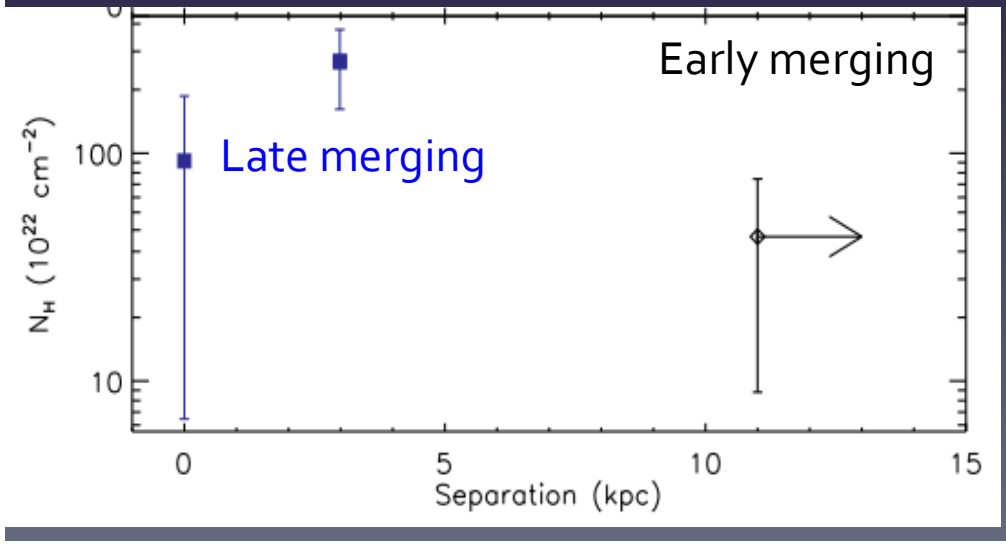




Obscuration *vs* merging

X-rays+SDSS: 60% of our sample is obscured





GOALS, Swift/BAT. Ricci+17

i) AGN in late mergers are more obscured than those in early mergers and isolated AGN

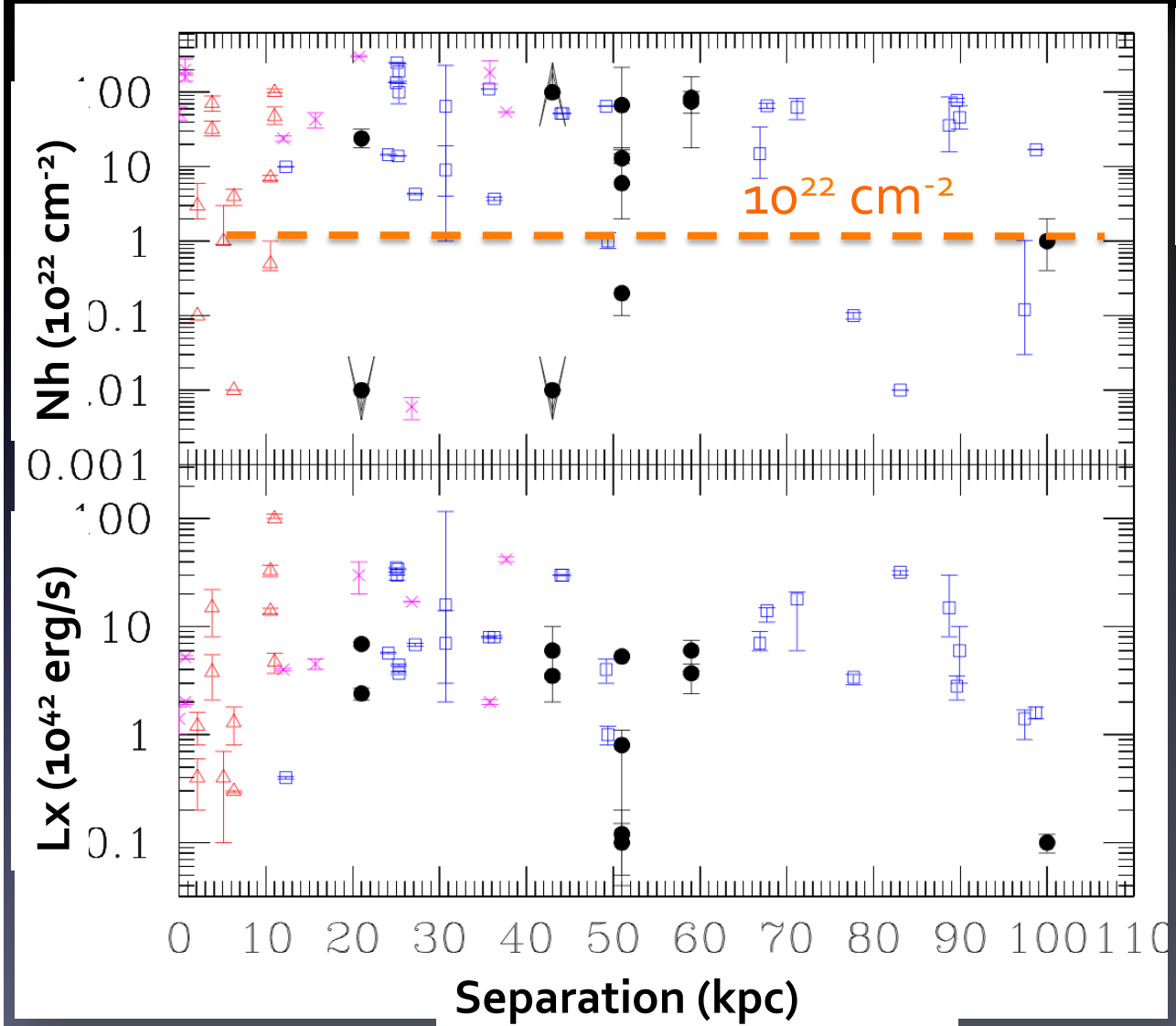
ii) AGN in late mergers have NH ≥ 10^{23} cm^{-2}

iii) Obscuration peak at a distance of 0.4–10.8 kpc

iv) Marginal evidence of decrease of NH at D< 11 kpc (feedback from the final AGN remove obscuration?)

SMBH growth caused by mergers (Treister+12)

Dual system hosting AGN observed in X-rays



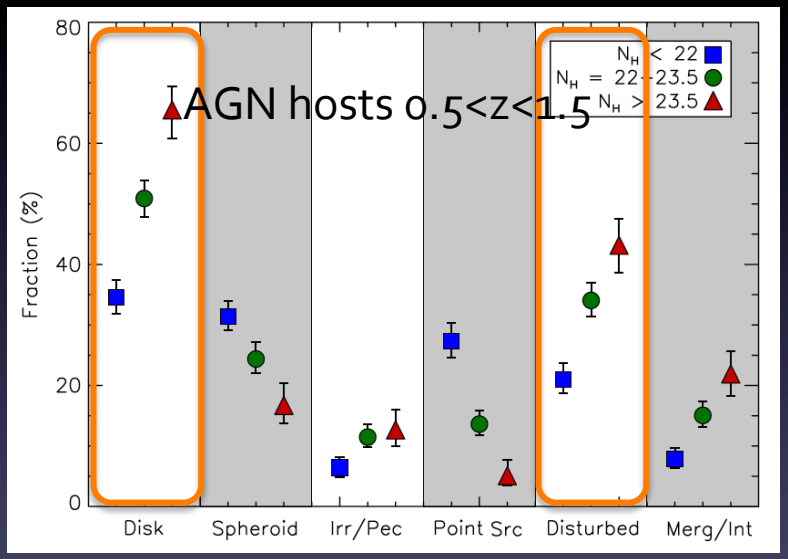
De Rosa+17,Koss+10, Ricci+17

- Our systems
- Δ SDSS detected
- □ Hard-X detected (Koss+12)
- × IR detected (Ricci+17)

Type 1 unabsorbed AGN are unusual in merging/interacting systems.
BUT they start to emerge at separation <60 Kpc

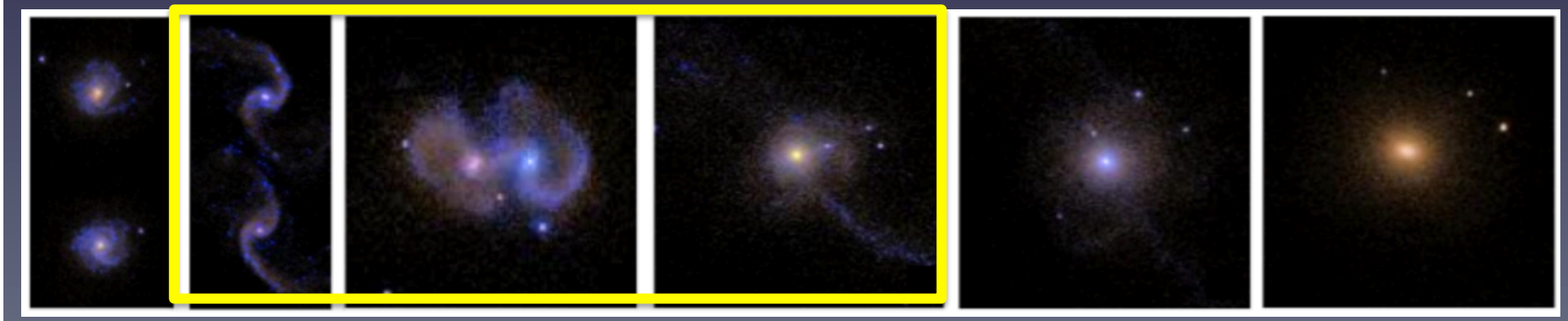
Obscuration vs morphology

Four morphologies: disk, Sp, Irr/ Pec, Point Source
Three degrees of disturbance: disturbed, Interacting, Undisturbed.



1. *Hosts of heavily obscured AGN are likely to be associated disturbed morphology*
2. *Merger-driven co-evolution predicts a strong dependence between obscuration and host properties such as morphology (Cattaneo+05; Hopkins+08)*
3. *obscured SMBH growth is a distinct phase in an evolutionary sequence following a merger event*
4. *AGN UM cannot explain such a correlation*

CDFS, C-COSMOS, AEGIS-XD. Kocevski+15



Summary

We studied a multiband data of an optically selected sample of multiple galaxies hosting AGN

- ✓ Obscuration (10^{22} cm-2) is present about 60% of the sample
- ✓ SFR increases for the closest separation systems (20 kpc)
- ✓ Evidence of outflows in the closest systems (<40 kpc)
- ✓ "unusual" type 1 AGN are found in almost half of the sample

Work in progress

- ✓ on-going VLA study of AGN pairs at very high angular resolution at 5 and 10 GHz: core-jet structures and environments
- ✓ Chandra data for systems at lower separation (<10")
- ✓ HCG J0959 a case MUSE - VLA eEVN observation

Thanks for your attention!